## NOBLE GASES IN TERRESTRIAL DIAMONDS: PRELIMINARY RESULTS

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Motivated by exciting, but puzzling, noble gas results in terrestrial diamonds (e.g. high $^3He/^4He$ ratios close to the solar value from industrial class diamonds [Ozima *et al.*, 1983] and low $^{40}Ar/^{36}Ar$ [ = 189] from an Arkansas, U.S.A., diamond [Melton and Giardini, 1980]), we undertook the study of noble gases in diamonds from different locations. Although this is ongoing research, we can report preliminary results, some of which require confirmation. We have measured 15 diamond samples: Premier type I; Finsch type II; De Beers pool type I and II; Zaire; Arkansas; Australian (two samples); Brazilian (three); and industrial class diamonds, probably of South African origin (four). One industrial class diamond was successively heated for 30 minutes at 1200, 1700, 2000 and 2050°C. The fractional releases of $^4He$ were 0.007, 0.027, 0.964, and 0.002, respectively. All the He was confirmed to be released along with the 2000°C graphitization of the sample. All other samples were graphitized at 2000°C for noble gas analysis.

The $^3He/^4He$ ratios are characterized by a large spread ($10^4$), ranging from values below atmospheric to values in excess of the planetary (but not the solar) ratio. The highest $^3He/^4He$ value ($1.57 \pm 0.75$; $\pm 1\sigma$) $\times 10^{-4}$ was observed for an Australian colorless diamond composite, while the lowest ($< 4.5 \times 10^{-8}$) was for an Australian colored diamond composite which, interestingly, came from the same kimberlite pipe. The Australian colorless sample gave an imprecise but intriguing $^{20}Ne/^{22}Ne$ ratio ($12.6 \pm 1.6$), close to the solar vlaue. We are planning to measure more Australian samples of greater size in order to increase the precision of the isotopic abundance ratios.

We measured one Arkansas diamond (Smithsonian catalog #125974), which was crushed and analyzed for Ar isotopes by Melton and Giardini but did not yield them a publishable value for the ratio $^{40}Ar/^{36}Ar$. We found $^{40}Ar/^{36}Ar$ of $670 \pm 140$ and $[^{40}Ar] = 9.4 \pm 2.4 \times 10^{-8}$ ccSTP/g, which conflicts with their results for another Arkansas sample which gave the result quoted above. A high $^4He$ concentration ($= 1.77 \pm 0.05$) $\times 10^{-4}$ ccSTP/g was observed from this sample as well as a definite contribution from fissiogenic Xe. The ratio of fissiogenic $^{136}Xe$ to $^4He$ is $8.9 \pm 4.5 \times 10^{-10}$, which agrees within error with the current production ratio for radioactive decay of U and Th (assuming Th/U = 3.3 by weight). The high enrichment of $^4He/^{40}Ar$ ($> 10^3$ where typical values for mantle-derived materials are 1-20) may indicate that U was enriched relative to K in the source region and/or elementally fractionated during crystallization of the diamond.

None of the samples showed any significant excess $^{129}Xe$.

Melton, C.E. and A.A. Giardini, 1980. *Geophys. Res. Lett.* **7**, 461.
Ozima, M. *et al.*, 1983. *Geochim. Cosmochim. Acta* **47**, 2217.

## FURTHER EVIDENCE FOR EXTENSIVE METASOMMATISM OF THE ALLENDE PARENT BODY

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The Allende meteorite contains a number of minerals which are uncommon to rare in meteorites generally. A significant fraction of these occur with similar textures and compositions in the three major components, chondrules, matrix, and CAI. Minerals in this category include nepheline, sodalite, pentlandite, awaruite, and hercynite.

The simplest interpretation of this observation is that these minerals formed in all components while they were in the same environment and at the same time. If they formed, for example, while matrix was in one environment and chondrules were in another, then

they should be more abundant in either matrix or chondrules of other unequilibrated meteorites.

It is also simplest to assume the required environment was on a parent body. If it was a nebular setting the Allende material would in any case have had to accreate onto a parent body rapidly to avoid being mixed with more ordinary CV3 material.

New scanning electron microscope data on the distribution of hercynite in chondrules and matrix will be presented. Generally, it occurs as submicrometer grains in altered regions and is frequently associated with pentlandite. This latter suggests a low temperature mode of origin.

Combining these observations with all previous results, it appears that during metasommatism iron, sulfur, alkalies, aluminum, and to some extent silicon have moved while calcium has been relatively immobile. This leads to the speculation that the observed metasommatism was mediated by a chlorine rich vapor phase.

## OXYGEN ISOTOPES AND PRE-SOLAR DUST IN THE EARLY SOLAR SYSTEM

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The oxygen reservoirs in the solar system were inherited from the cold molecular cloud from which the sun formed, not from a hot gas of solar composition (Huss, 1985). About 75-80% of the oxygen in the pre-solar cloud was probably present in gaseous compounds ($CO$, $CO_2$, $H_2O$), while the remainder was in dust grains as metal oxides ($MgO$, $FeO$, $CaO$, $SiO_2$) (Savage and Mathis, 1979). Gaseous oxygen was probably isotopically homogeneous. Dust grains preserved the oxygen composition of their formation site, and the dust cloud was probably a well stirred mixture of diverse grains (Huss, 1985).

There is a correlation between refractory chemistry and $^{16}O$ enrichment in meteoritic material (Wark and Brown, 1984), suggesting that refractory dust grains in the pre-solar cloud were $^{16}O$ enriched. Elmegreen (1981) suggested one mechanism that might produce such $^{16}O$ enriched refractory material, through the interaction of molecular clouds and shock waves associated with supernovae. Dust in the molecular cloud might thus be considered to reside in two reservoirs: a refractory $^{16}O$-enriched reservoir that makes up a small fraction of the dust, and an $^{16}O$-poor reservoir consisting of material of varying volatility.

As the solar system formed, the gaseous and solid oxygen reservoirs were modified in several ways. 1) Mixing of reservoirs by gas-solid exchange affected some material (Wood, 1981; Clayton *et al.*, 1977). If gas and solid reservoirs achieved equilibrium, their isotopic compositions would differ, but would be related by known fractionation factors. 2) Removal of the more volatile components of the dust, probably through evaporation (Huss, 1985), would result in evolution of reservoir compositions. The bulk dust would become more $^{16}O$ rich as the more volatile, $^{16}O$-poor material evaporated. If the gas is removed from a particular part of the solar system, the new gas phase evolved by evaporation of increasingly refractory dust would also become increasingly $^{16}O$ rich. 3) Once large solid bodies formed, equilibration of oxygen the composition within the bodies could occur, removing direct evidence of the starting material.

The CI chondrites probably accreted an average sample of molecular cloud oxygen, since they apparently formed from bulk samples of the pre-solar cloud (Huss, 1985). This composition probably was $\delta^{17}O = 5.5 \pm 1‰$, $\delta^{18}O = 7.5 \pm 1‰$. The terrestrial planets and differentiated meteorites formed from material that had lost the most volatile components, with bulk oxygen composition evolving to $\delta^{17}O = 3.5 \pm 1‰$, $\delta^{18}O = 7.0 \pm 1‰$. The C2 and C3 chondrites have bulk compositions more enriched in $^{16}O$ because they contain a higher percentage of refractory material. In addition, they have not been internally equilibrated, thus preserving the correlation between $^{16}O$ and refractory chemistry in individual grains. Simple CAIs are probably the most spectacular examples of the $^{16}O$ enriched refractory material formed in interstellar space.